Liquefaction Resistance of Partially Saturated Christchurch Soils

Baki, M. A. L; Cubrinovski, M. & Stringer, M., University of Canterbury
abdul.baki@canterbury.ac.nz; misko.cubrinovski@canterbury.ac.nz; mark.stringer@canterbury.ac.nz

BACKGROUND

- Past field investigations on Christchurch soil deposits show that, in some locations, the top part of the deposit is partially saturated at 1.0 m, or larger depths below the ground water table.
- Also, simplified methods for liquefaction assessment predicts moderate-to-severe liquefaction over large areas of Christchurch where no liquefaction manifestation was observed (Maurer et al. 2014).
- Therefore, this research aims to establish V_p-based filed procedure for quantification of soil saturation in-situ and evaluate liquefaction resistance of partially saturated Christchurch soils.

EXPERIMENTAL PROGRAM

- Undrained cyclic triaxial tests on two Christchurch soils, sand with 3% fines content (FC) and a silty sand with FC=30%, were conducted at different B-values.
- P-wave and S-wave velocities (V_p and V_s respectively) were measured before cyclic testing. For some tests, V_p and V_s were measured throughout the tests at different B-values.
- Soil specimens of 61 mm diameter and 130 mm height were prepared by moist tamping method.
- Soil properties are: G=2.67, e_{max} = 1.048, e_{min} = 0.635, D_{50}=0.24 mm (sand) and G = 2.69, e_{max} = 1.154, e_{min} = 0.646, D_{50}=0.11 mm (silty sand). Figure 1 shows PSD of tested soils.

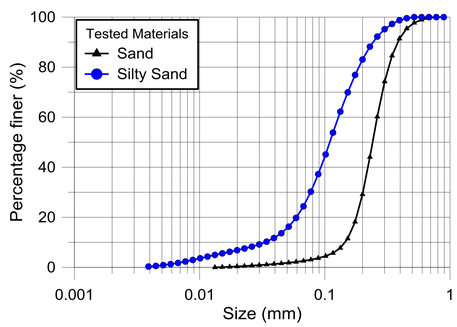

Figure 1: Particle size distribution (PSD) of tested soils.

TEST RESULTS-SAND

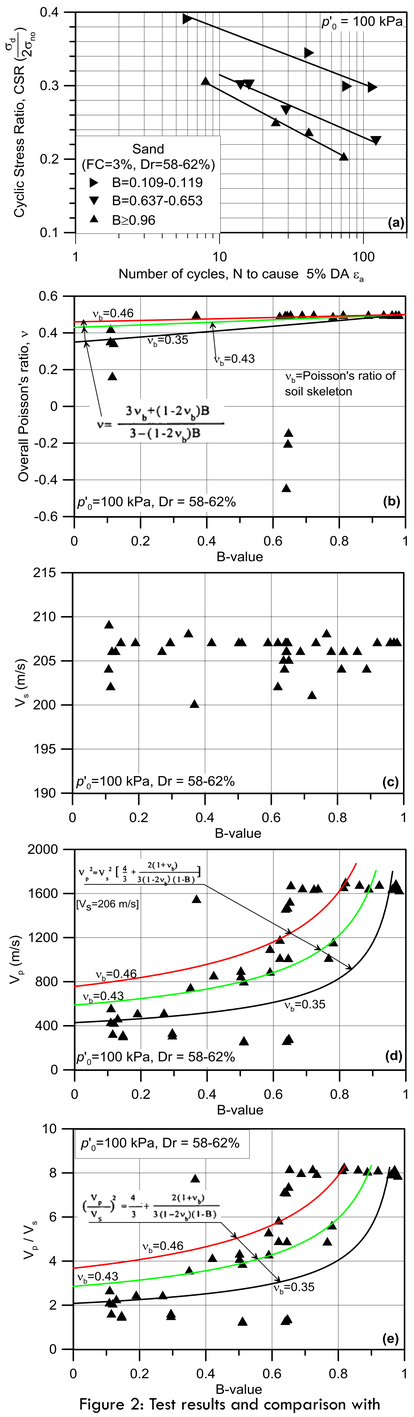

Figure 2: Test results and comparison with theoretical relationships for sand .

TEST RESULTS-SILTY SAND

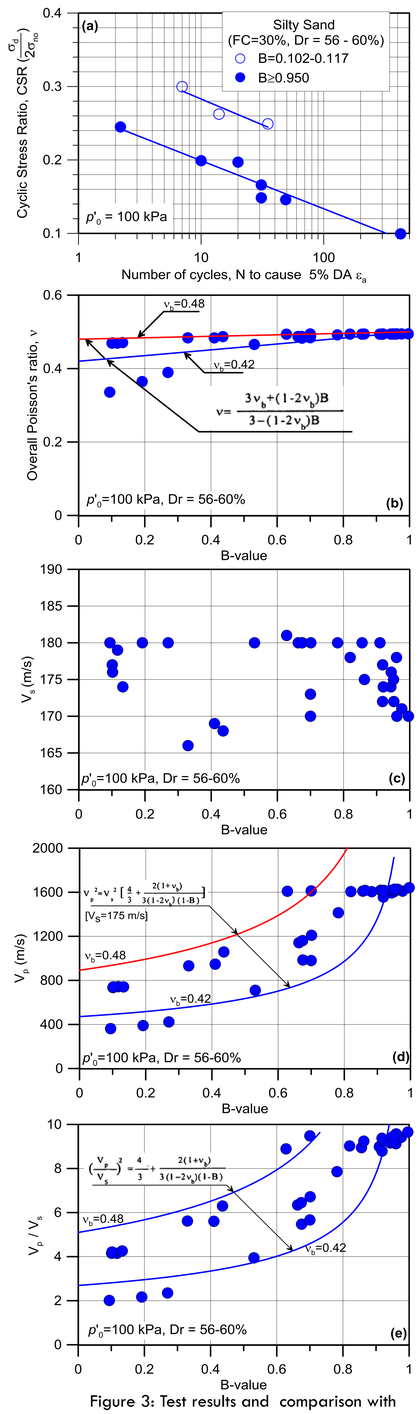

Figure 3: Test results and comparison with theoretical relationships for silty sand .

ANALYSIS OF TEST RESULTS

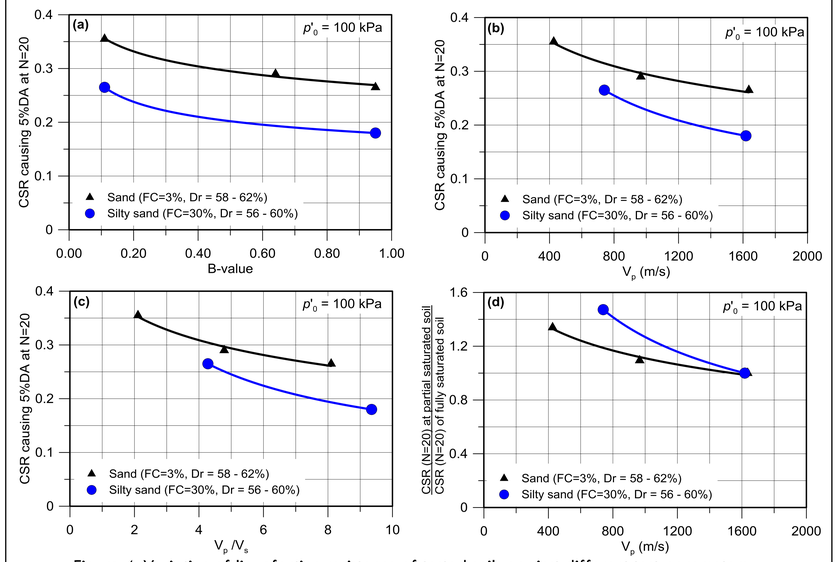

Figure 4: Variation of liquefaction resistance of tested soils against different test parameters.

RESEARCH FINDINGS

- Shear wave velocity of tested sand varied between 200 m/s and 208 m/s whereas it varied from 166 m/s to 181 m/s for tested silty sand (Fig 2c & Fig. 3c).
- For sand, V_p values were close to 1600 m/s or higher at B=0.65 onwards (Fig. 2d) whereas for silty sand, at B=0.80 onwards (except two data points) V_p was around 1600 m/s (Fig. 3d).
- When B-value drops to 0.10, cyclic strength becomes 1.34 times higher than that at full saturation with B≥0.95 for sand whereas it is 1.37 times higher for tested silty sand (Fig. 2a, Fig. 3a & Fig. 4).
- For both tested soils, the ratio of P- to S-wave velocity (V_p/V_s) can be expressed as a function of the skeleton Poisson's ratio, ν_b, and the B-value to represent overall data trend (Fig. 2e & Fig. 3e). This finding is in agreement with the literature (Tsukamoto et al., 2002).
- It is possible to correlate B-value with in-situ measured values of V_p & V_s and hence liquefaction resistance in the field.

REFERENCES

Maurer, B., Green, R., Cubrinovski, M., and Bradley, B. (2014). "Evaluation of the Liquefaction Potential Index for Assessing Liquefaction Hazard in Christchurch, New Zealand." J. Geotech. Geoenviron. Eng., 140 (7): 04014032

Tsukamoto, Y., Ishihara, K., NakaZawa, H., Kamada, K., and Huang, Y. 2002. Resistance of Partly Saturated Sand to Liquefaction with Reference to Longitudinal and Shear Wave Velocities. Soils and Foundation 42(6): 93-104.